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Original Article

Bipolar Hip Arthroplasty Using a Conjoined Tendon-preserving Posterior Approach in Geriatric Patients

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In bipolar hemiarthroplasty (BHA), it is important to preserve soft tissue to reduce the risk of postoperative dislocation. A variety of surgical approaches for BHA are available, but extra care is needed with muscle- and tendon-preserving approaches in geriatric patients. We investigated the usefulness of BHA using a conjoined tendon-preserving posterior (CPP) approach, in which only the external obturator muscle is dissected, in geriatric patients. We retrospectively analyzed the cases of 40 femoral neck fracture patients (10 men, 30 women) aged ≥80 years who underwent BHA using the CPP approach. The patients' average age was 85.8 years (80-94 years). We examined the operation time, bleeding, preservation of short external rotator muscles, complications, and stem alignment and subsidence from postoperative radiographs. Although gemellus inferior muscle injury was detected in 4 patients (10%), the hip joint stability was very excellent in all cases. There was no intraoperative fracture or postoperative dislocation. On postoperative radiographs, all femoral stems were in a neutral position. There was no stem subsidence in all 40 patients. BHA using the CPP approach appeared to be useful even in geriatric patients.

Key words: bipolar hip arthroplasty, geriatric patient, conjoined tendon-preserving posterior approach

The dislocation rate in the conventional posterior approach in bipolar hemiarthroplasty (BHA) is double that in the anterior approach [1,2]. However, immobilization to reduce the risk of postoperative dislocation after a BHA can delay the patient's rehabilitation [3]. Preserving soft tissue in a BHA is important for reducing the risk of postoperative dislocation, and a variety of surgical approaches have been reported recently considering this complication [4]. The piriformis tendon preservation technique during the posterolateral approach in total hip arthroplasty (THA) is reportedly superior to the reattachment technique in terms of contiguity, muscle atrophy, and dislocation [5]. Kim *et al.* reported a THA method that preserves muscles from the piriformis muscle to the internal obturator muscle (*i.e.*, an external rotator preservation procedure [ERP]) and had good outcomes with no cases of postoperative dislocation [6].

We have performed BHAs using a conjoined tendon-preserving posterior (CPP) approach, which dissects only the external obturator muscle and preserves the gemellus inferior muscle. However, extra care is needed with muscle- and tendon-preserving approaches in geriatric patients. We conducted the present study to evaluate the intraoperative findings and

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postoperative courses of patients aged ≥80 years who underwent a BHA by the CPP approach. We hypothesized that the CPP approach could be suitable for geriatric patients with fragile soft tissue.

Patients and Methods

Patient selection and study design. This was a retrospective review of 40 consecutive geriatric patients aged ≥80 years who underwent a BHA using the CPP approach at our hospital during the period from February 2017 to March 2018, approved by the Ethics Committee of our institution. The patients were 10 men and 30 women, mean age 85.8 years (range 80-94 years). The mean height was 152 cm (range 141-168 cm), and the mean body mass index was 19.3 kg/m^2 (range 17.1-25.6 kg/m^2). The average postoperative follow-up period was 26 months (range 24-36 months). The preoperative diagnosis was a femoral neck fracture for all 40 patients. The Garden classification of the fracture type [7] was III for 12 hips (30%) and IV for 28 hips (70%).

The femoral components used for these patients were the M/L Taper Hip Prosthesis with Kinectiv Technology (Zimmer Biomet, Tokyo) for 32 patients, the Alloclassic-SL^{TM} system (Zimmer Biomet) for 6 patients, and the PerFix HA femoral stem (Kyocera Medical, Kyoto, Japan) for 2 patients. The M/L Taper Hip Prosthesis with Kinectiv Technology is a modular femoral stem system, and with it the femoral offset and leg length can be changed independently [8]. The Alloclassic-SL system is a titanium alloy straight femoral stem with press-fit primary fixation with a forged titanium alloy (Protasul-100^{TM}) in which niobium is replaced with vanadium. The PerFix HA femoral stem is a straight femoral stem that is coated with hydroxyapatite by a titanium arc-spray technique [9]. A 28-mm ceramic femoral head was used in all hips. The Dorr classification of the bone type [10] was A for two hips (5.0%), B for 14 hips (35%), and C for 24 hips (60%). The mean postoperative follow-up period was 14 months (range 12-24 months).

Surgical procedure and postoperative care. The BHA surgery is performed with the patient in the lateral decubitus position. A pelvic fixation device that has sacral and iliac pads is used to create a stable pelvis. A 10-cm skin incision is made posteriorly at a 45° angle from the posterior margin of the tip of the greater trochanter (Fig. 1A). The gluteus maximus is separated along its fibers to expose the posterior margin of the gluteus medius and the short external rotator muscles. The sciatic nerve is distinguished during this step, and the surgery is performed while confirming the nerve's position and protecting it. At this time, it is important to identify the external obturator muscle and trochanteric branch of the deep medial circumflex femoral artery. This artery should be cauterized at the proximal margin of the quadratus femoris muscle.

Starting proximally, the surgeon identifies the piriformis, gemellus superior, internal obturator, gemellus inferior, and external obturator muscles (Fig. 1B). The capsule is incised posteriorly along the caudal margin of the gemellus inferior muscle. The incision is extended distally along the posterior border of the femur, and the external obturator muscle and capsule are then inverted (Fig. 1C). The quadratus femoris muscle is preserved. The external obturator muscle and gemellus inferior muscle are threaded, respectively.

Next, after the osteotomy of the femoral neck completed, the femoral head is removed. Performing the osteotomy of the femoral neck beforehand makes it easier to remove the femoral head without muscle damage. The femoral head is measured, and a trial cup is inserted into the acetabulum to determine the size of the outer head.

Femoral broaching is performed while preserving and making sure not to damage the piriformis muscle and conjoined tendon covering the intertrochanteric notch. The optimal stem size is then determined (Fig. 1D). An inner head and outer head of appropriate lengths are put in place to perform a trial reduction. The most difficult part of this surgical technique is the manual reduction. The hip joint is reduced after flexing the hip joint until the stem and conjoined tendon are parallel without excessive traction. In addition, the reduction is performed with the hip in mild abduction so that there is no tension on the conjoined tendon. If the outer head can move to the acetabulum, the reduction can be performed by pushing in the outer head.

After confirmation that there is no leg length discrepancy, an implant of the same size is inserted (Fig. 1E, F). The L-shaped incisions of the external obturator muscle and capsule are repaired, and the wound is then closed after irrigation (Fig. 1G, H). All 40 of the present patients began full weight-bearing exercises and range of motion exercises without restric-

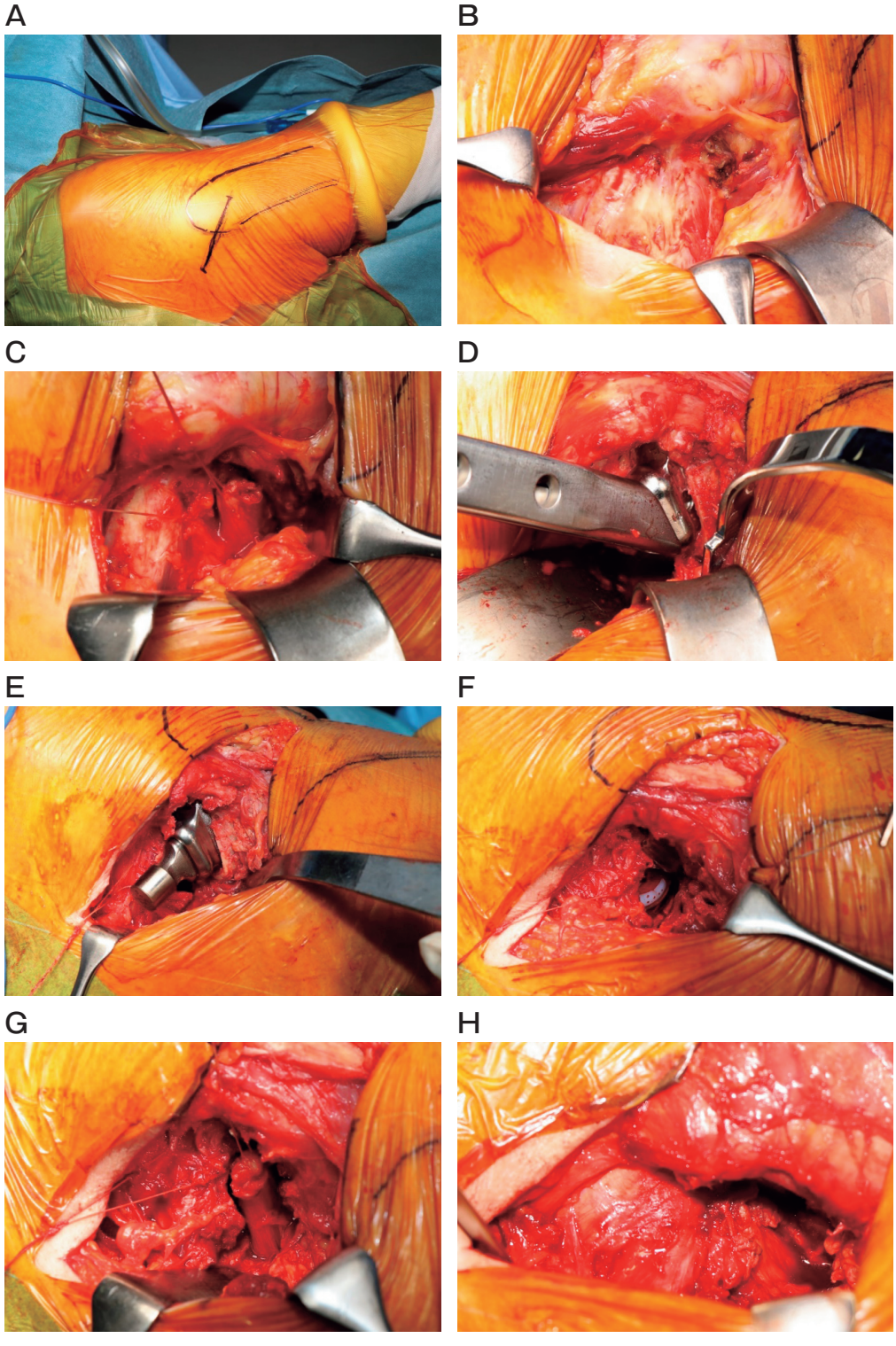

Fig. 1 A, Skin incision; B, Short external rotator muscles; C, The L-shaped incision in the external obturator muscle and capsule; D, Femoral broaching; E, Stem insertion; F, After implant reduction. Before (G) and after (H) the repair of the external obturator muscle and capsule.

tion on postoperative day 1. No brace, such as that with contraindicated limb positions or abduction pillows, was used.

Evaluations. We examined the operation time, bleeding, preservation of short external rotator muscles, complications, stem alignment [11], and subsidence from postoperative radiographs. Preservation of the short external rotator muscles was assessed by the operator by checking whether any of the thread placed in the gemellus inferior muscle at the beginning of the operation remained when the wound was closed. Hip function was evaluated using the Harris Hip Score (HHS) [12] and Japanese Orthopaedic Association (JOA) hip score [13]. The JOA hip score allocates 40 points for pain, 20 points for range of motion, 20 points for walking ability, and 20 points for activities of daily living, with a maximum total score of 100 points.

Statistical analysis. The pre- and postoperative HHS and JOA hip scores were compared using a two-sample *t*-test. The differences were considered significant at a p-value < 0.05. The statistical analysis was conducted using SPSS for Windows ver. 25 (IBM, Armonk, NY, USA).

Results

The mean operation time was 58 min (range 40-75 min) and the mean intraoperative bleeding was 150 ml (range 50-350 ml). There were four patients (10%) whose gemellus inferior muscle was damaged; the Alloclassic-SL system was used in all four patients. There was no gemellus inferior muscle damage in the cases using the other stems. There were two patients (5%) whose gemellus inferior muscle was difficult to identify. The mean stem subsidence was 0.2 mm (range 0-1.6 mm); however, none of the patients showed significant subsidence (≥ 3 mm). On postoperative radiographs, all of the femoral stems were in a neutral position.

The pre- and postoperative (final follow-up) mean HHS hip scores were 83.4 points (range 71-97 points) and 82.5 points (range 67-96 points), and those of the JOA hip scores were 71.3 points (range 55-88 points) and 73.6 points (range 58-92 points). There was no significant difference between the HHS and JOA hip scores at before and after the BHA surgery ($p = 0.24$, 0.30, respectively). There were no cases of fracture, infection, sciatic nerve palsy, or dislocation intraoperatively or postoperatively, and none of the hips required revision. Postoperative deep venous thrombosis was confirmed in 4 patients (10%).

Discussion

We performed the BHA using a novel method, the CPP approach, in geriatric patients aged ≥ 80 years. Making the capsule incision between the gemellus inferior and external obturator muscles allowed us to preserve the conjoined tendons except for that of the external obturator muscle, in almost all of the patients.

The aging of society has led to a greater need for a BHA in geriatric patients. It can be difficult to instruct these patients on how to prevent dislocations due to their lack of understanding of limb positions that may cause dislocation. As hospital stays need to be shortened to reduce medical costs, there is a need for surgical methods that prevent dislocation because of daily activities, excluding falls and other accidents.

The most common conventional posterior approach involves incising the capsule and short external rotator muscles separately. Methods have recently been employed that incise the capsule and short external rotator muscles together instead of separately, or that only preserve the piriformis muscle. The short external rotator muscles and capsule play an important role in preventing hip dislocation. The short external rotator muscles and ischiofemoral ligament provide dynamic stability by controlling internal rotation, and the capsule provides static stability by acting as a posterior wall; both of these prevent dislocation. However, once the capsule and short external rotator muscles are cut, they have been found to re-rupture postoperatively at high rates (75-92%), even after being repaired [14, 15]. Han *et al.* performed BHAs using an ERP in femoral neck fracture patients with mental disorders [4], and they reported that compared with the conventional posterior approach, there were no differences in operation time or bleeding; however, the rate of postoperative dislocation was significantly lower.

The CPP approach preserves the anatomy from the piriformis muscle to the gemellus inferior muscle. Because this approach preserves the gemellus inferior muscle, we consider it superior to ERP at preventing postoperative dislocation. Moreover, all of the present patients were ≥ 80 years old. The gemellus inferior muscle was difficult to identify in 2 cases, and muscle-

tendon damage was observed in 4 cases. The Alloclassic-SL system was used in the 4 patients with gemellus inferior muscle damage. We suspect that these muscles were damaged by the shoulder of the stem during rasping. Therefore, when the CCP approach is used, we recommend the use of a taper wedge-type stem with a reduced stem shoulder.

That being said, due to individual differences in the shape of the conjoined tendon and external obturator muscle insertion sites, some degree of gemellus inferior muscle damage during rasping may be unavoidable. However, in the present series the hip joint stability was excellent in all cases and there were no cases of postoperative dislocation. The 4 cases with gemellus inferior muscle damage were highly resistant to posterior dislocation due to the intact posterior capsule and ischiofemoral ligament, which indicates that the CPP approach is useful in geriatric patients.

The 'Sparing Piriformis muscle and Internus, Repair Externus (SPAIRE)' technique is a muscle-sparing mini-posterior approach for a THA reported by Handy *et al*. [16]. This approach enables the preservation of the piriformis muscle tendon and a conjoined insertion of the obturator internus and the gemelli. However, a posterior capsulotomy is performed in an L-shape with a proximal oblique limb (at 10 o'clock for a right hip, 2 o'clock for a left hip) starting subjacent to the preserved quadriceps coxae tendons [16]. This approach therefore has 2 shortcomings: (1) the lower resistance to posterior dislocation from the posterior capsule compared to the CPP approach, and (2) due to the lack of a posterior capsule and the exposed conjoined tendon, the gemellus inferior muscle is more likely to be damaged than with the CPP approach.

Many inexperienced surgeons perform a BHA for femoral neck fractures. Although the posterior approach is technically simple and provides a good field of view, we believe that performing a BHA with the CPP approach would be easy for surgeons with some experience with the posterior approach, because this approach needs no specialized equipment. Although there is a surgery-related learning curve, the operation time is < 1 h, and if the surgical technique proves difficult the surgeon can switch to the conventional posterior approach. The CPP approach, which is highly resistant to posterior dislocation, can be considered a highly useful method for femoral neck fractures that accompany aging.

Our findings regarding the outcomes of the CPP approach are limited by the relatively small sample size (n = 40). Further studies with larger sample sizes are needed to test our results.

In conclusion, we attempted to preserve the short external rotator muscles in BHAs for geriatric patients by using the CPP approach. There were no intraoperative problems or postoperative dislocations, indicating that the CPP approach is useful for geriatric patients as well.

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